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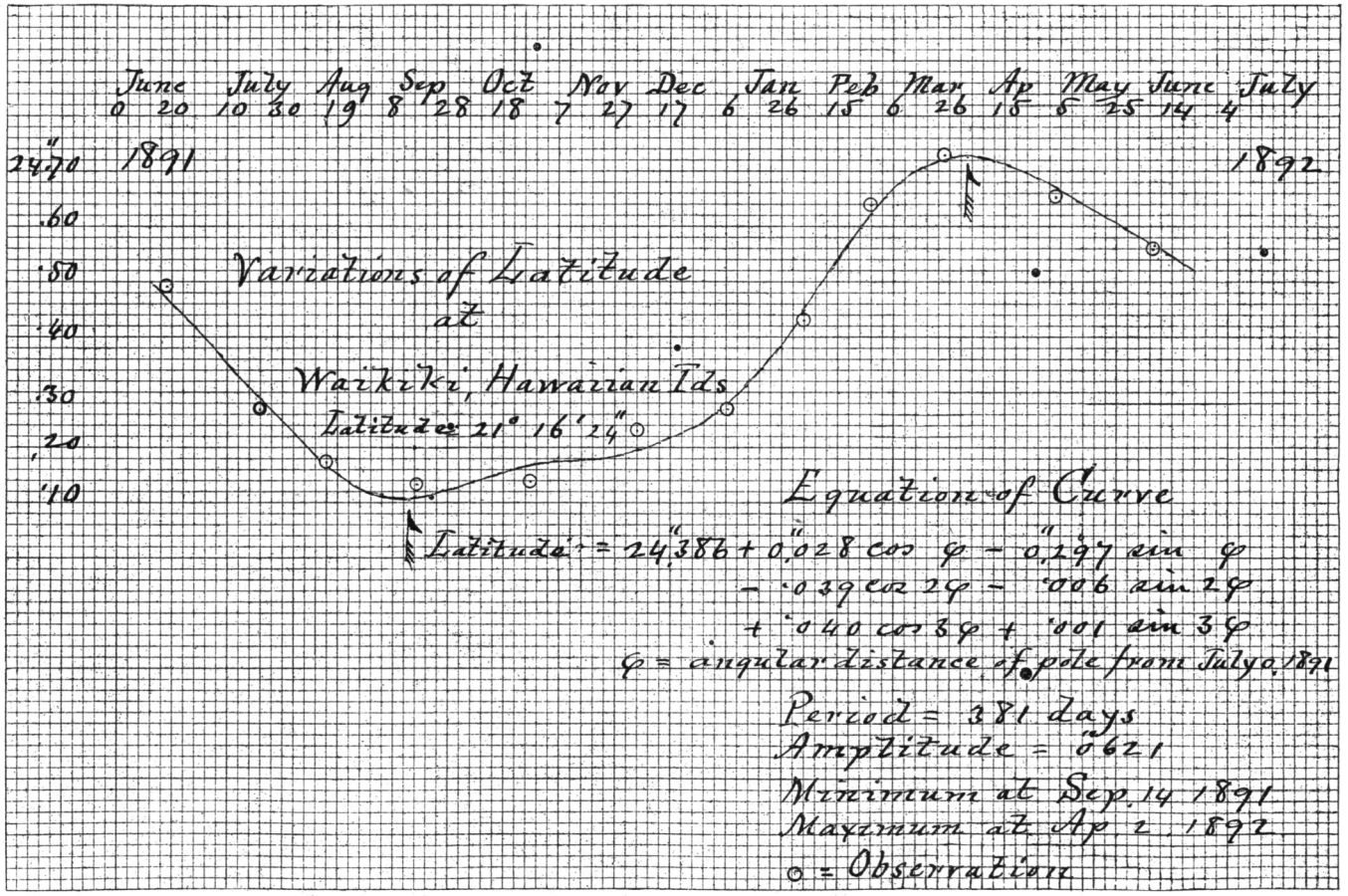
June July Aug Sep Oct Nov Dec Jan Feb Mar Ap May June July
0 20 10 30 19 8 28 18 7 27 17 6 26 15 6 26 15 5 25 14 4
24".70
.60
.50
.40
.30
.20
.10
1891
1892
Variations of Latitude
at
Waikiki, Hawaiian Ids
Latitude = 21° 16' 24"
Equation of Curve
Latitude = 24".386 + 0".028 cos φ − 0".197 sin φ
− .039 cos 2φ − .006 sin 2φ
+ .040 cos 3φ + .001 sin 3φ
φ = angular distance of pole from July 0, 1891
Period = 381 days
Amplitude = .621
Minimum at Sep. 14 1891
Maximum at Ap. 2 1892
⊙ = Observation

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VARIATIONS OF LATITUDE.

BY E. D. PRESTON.

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In the spring of 1891, the International Geodetic Association undertook observations of latitude in Germany and in the Hawaiian Islands. The question whether the variations of latitude, first brought out by Dr. KÜSTNER, were the result of a real motion of the axis of rotation of the Earth, or whether it was the effect of atmospheric or other conditions, could only be decided by simultaneous observations in widely different longitudes. The Association therefore detailed Dr. MARCUSE of the Berlin Observatory for this work, and asked the coöperation of the U. S. Coast and Geodetic Survey, which service was represented by the writer. The two observers left Washington on the 18th of April, 1891, and arrived at Honolulu on the 8th of May. After observing the Transit of Mercury, on the following day preparations were made for the objective work of the trip, and the observatories were built at Waikiki. During the first days of June the regular astronomical observations began, and they were continued without interruption until the last days of June of the following year. In the American observatory attention was given to other subjects, and during the year nearly one thousand determinations of the relative force of gravity were made. These have not been completely reduced, but will probably be ready for publication, together with other gravity, magnetic and latitude determinations made throughout the islands, in the course of a few months.

In the International Association observations at Waikiki, about 2400 separate determinations of the ϕ were made on the

part of the Coast and Geodetic Survey. The stars observed comprised 63 pairs, divided into 8 groups. These were selected by Dr. MARCUSE in Berlin, and were made the subject of careful study. All the usual conditions in the selection of latitude stars, regarding zenith distance, magnitudes, etc., were attained, and, moreover, most of the stars observed were from BRADLEY'S List, so that their proper motions were quite accurately known.

The difference in the latitude of the two observatories was 0″.3, the American one being the more southern. In addition to this, the mean places adopted in the Coast Survey Office for the stars employed placed this observatory still nearer the equator by 0″.2, so there is an almost constant difference 0″.5 in the latitudes as determined by the two parties.

In reducing the observations we have followed Professor ALBRECHT'S treatment of Dr. MARCUSE'S work, except in the manner of distributing the error of closing and other outstanding errors, which were adjusted by the method of least squares.

After the individual values for the latitude were obtained, each group was reduced to its own mean declination system by comparing the mean value of the latitude from any one pair with the mean value deduced from all the pairs. For those nights on which incomplete groups were observed, the mean for the observed pairs was corrected by applying the mean of the quantities necessary to reduce the separate pairs to the mean declination system. On complete nights, of course the mean of all the pairs gave immediately the value sought. The relations which each one of the mean declination systems bore to each other was established by subtracting the mean for each group from the mean of the next following one, and the sum of these differences for the whole series gave the error of closing. If this were the only condition to be satisfied, it should be distributed inversely proportional to the number of pairs forming the group connections. But as during the year, at three different times, the observations were made to include three groups each night instead of two, and moreover, as Group II was re-observed in 1892, as well as Group I, there appear five rigorous conditions to be satisfied, instead of one.

After the least square adjustment the daily means were obtained. These were deduced by combining all the observations on each date for all the groups observed. Each group being reduced to its mean declination system and then corrected by a

quantity depending on the relation between the groups, so as to place them all on the basis of one homogeneous series, weights were applied to each value, and the weighted mean gave the resulting latitude for the day. The weights applied depend on the number of pairs of stars observed. In order to further condense the results, and enable us to represent them graphically on a convenient scale, several successive nights were treated together.

The arrangement was such that each value had about the same weight, and on the average this was equivalent to that of about 40 pairs observed on four nights.

After plotting the results, a period of 415 days was assumed for a complete revolution of the pole, and an equation was deduced depending on the sine of the angular distance of the pole from an assumed position at a given time. This equation being compared with the actual observations, showed that the period adopted was too long, and that the addition of a second periodic term depending on the cosine would improve the agreement and give a curve more closely representing the variations of latitude.

The equation used was:

$$\phi = \phi_0 - 0''.311 \sin nt + 0''.037 \cos nt,$$

where ϕ is the latitude at the time t counted in days from July 0, 1891.

ϕ_0 = the mean latitude = 24″.40.
n = angular daily motion of pole.

The period taken is 378 days, and the amplitude is 0″.62.

The minimum falls on October 2, 1891, and the following maximum on April 9, 1892. This curve, and the observations from which it was deduced, is shown in the Frontispiece. In order to treat the observations by least squares and discover any terms in the periodic function depending on multiple angles, the values were condensed by taking means of successive groups of four, and the following dates and corresponding latitudes were derived:

1891, June 18..	24″.492	1892, Jan. 7..	24″.272
July 22..	.265	Feb. 3..	.432
Aug. 15..	.175	Feb. 27..	.640
Sep. 17..	.135	Mar. 24..	.728
Oct. 28..	.138	May 3..	.656
Dec. 5..	.232	June 7..	.560

These values are represented by the equation:

$$\begin{aligned}\text{Latitude} = 24''.386 &+ 0''.028 \cos \phi - 0''.297 \sin \phi \\ &- .039 \cos 2\phi - .006 \sin 2\phi \\ &+ .040 \cos 3\phi + .001 \sin 3\phi\end{aligned}$$

where the period of 381 days and the values are counted from July 0, 1891. The maximum is at April 2, 1892, and the minimum at September 14, 1891. The amplitude is $0''.621$. ϕ is the angular position of the pole.

A bulletin, containing fuller information and further details, is now in course of publication by the U. S. Coast and Geodetic Survey, and copies may be obtained by application to the Superintendent.

MEAN MONTHLY AND ANNUAL BAROMETRIC AND THERMOMETRIC READINGS AT MOUNT HAMILTON, 1880–1892.

Following is a table of observations of the barometer and thermometer, more or less complete, taken at the LICK Observatory from September, 1880, up to and including December, 1892, by monthly and yearly means. Observations are wanting during the interval from November, 1885, to June, 1888, inclusive. It should be mentioned that the observations for temperature from September, 1880, to October, 1885, were made with the thermometer in a wooden box at one of the cottages, some seventy feet below the LICK Observatory, and it is probable that the results indicate a higher temperature than those following, which were taken under the usual Signal Service conditions.

As indicated, a portion of the results for temperature is deduced from the mean of the maximum and minimum thermometers, while the remainder is obtained from readings of the dry bulb, taken at 7 A. M., 2 P. M. and 9 P. M. by the formula $\frac{7+2+9+9}{4}$. The barometric observations for 1888, 1889 and 1890 are reduced to the freezing point, 32° F., as indicated. An aneroid barometer was employed before 1888.

No monthly means in this list were accepted which were not obtained from observations on at least 19 days. While the data here presented are not as complete as might be desired, they are the best available. C. D. PERRINE.

LICK OBSERVATORY, May 20, 1893.